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INFLUENCE OF ENERGY INTAKE DURING LACTATION ON SUBSEQUENT GESTATION, LACTATION AND POSTWEANING PERFORMANCE OF SOWS[1]

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Summary

Forty-four second parity crossbred sows were used to determine (1) the effect of energy intake during their first lactation (Lac 1) on subsequent reproductive performance from rebreeding to farrowing and (2) the effect of energy intake during two successive lactations on performance during the second lactation (Lac 2) and postweaning periods. Sows received 8 (Lo) or 16 (Hi) Mcal of metabolizable energy (ME)/d during Lac 1 and 5.4 Mcal of ME/d during the subsequent gestation. Following parturition (i.e., Lac 2), sows fed Lo during Lac 1 were assigned to either the Lo or Hi diet. Similar assignments were made for sows fed Hi during Lac 1. Following parturition pigs were transferred among sows irrespective of treatment to minimize litter size variation. During the 28-d lactation period, all sows were fed an equal amount of crude protein, vitamins and minerals that met or exceeded the recommendations of the National Research Council. Each day following weaning, sows were fed 1.8 kg of a 14% crude protein diet and checked for estrus using boars. Serum samples were obtained weekly from sows not detected in estrus by 15 d postweaning for progesterone analysis. Sows fed Lo during Lac 1 gained more ($P = .1$) net weight, deposited more ($P<.01$) backfat during gestation and farrowed lighter weight ($P<.10$) pigs than sows fed Hi. Farrowing rate (i.e., number of sows farrowed/number mated) and the number of pigs born were not affected by energy intake during Lac 1. During Lac 2, sow weight loss, average litter size at weaning, pig weaning weight and the percentage of sows in estrus by 7, 14, 21 and 70 d postweaning were not significantly affected by energy intake during Lac 1. Sow backfat loss during Lac 2 differed depending on the energy intake during Lac 1 and 2, resulting in an interaction ($P<.05$). Sows fed Lo during Lac 2 lost more ($P<.01$) weight and weaned lighter weight ($P<.05$) pigs than those fed Hi. Litter size at weaning was not affected by energy intake. Fewer sows fed Lo expressed estrus ($P<.05$) by 7, 14 and 21 d postweaning than those fed Hi. Six sows fed Lo were bled for progesterone analysis. None of these had luteal tissue activity in the absence of a detected behavioral estrus.

(Key Words: Sows, Energy, Gestation, Lactation, Postweaning Estrus.)

Introduction

A variety of factors that influence the interval from weaning to first estrus in sows have been described previously (Reese et al., 1982). Elsley et al. (1968), O'Grady et al. (1973) and Adam and Shearer (1975) determined that the interval from weaning to first estrus was not affected when sows were fed 12 to 20 Mcal of digestible energy daily during three or more lactations. Reese et al. (1982) reported that energy intake during one lactation had a marked influence on the subsequent interval from weaning to first estrus. Sows that had large weight and backfat losses during lactation had a higher incidence of anestrus following weaning than those that had lost little weight and backfat.

Therefore, an experiment was conducted to determine (1) the effect of energy intake during

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the first lactation (Lac 1) on subsequent sow reproductive performance from rebreeding to farrowing and (2) the effect of energy intake during two successive lactations on performance during the second lactation (Lac 2) and postweaning periods.

Experimental Procedure

Details of the sows and diets used in this experiment have been described previously (Reese et al., 1982) and were those used in Exp. 1 of that study. Primiparous sows were fed either a low (Lo) or high (Hi) energy diet during Lac 1 (figure 1) that consisted of a daily caloric intake of 8 or 16 Mcal of metabolizable energy (ME)/sow, respectively. Sows that returned to estrus within 35 d of weaning were mated to fertile boars, kept inside gestation crates and fed 1.8 kg/d of a gestation diet[5] (Gest) until parturition. On d 110 of gestation the sows were moved into farrowing crates located in environmentally controlled rooms. Following parturition (i.e., Lac 2), 10 of the 19 sows that received Lo during Lac 1 were assigned to Lo and the other nine sows were allotted to Hi (figure 1). The 25 sows that were fed Hi during Lac 1 were also randomly divided between the Lo and Hi diets during Lac 2.

Following parturition and weaning, sows were weighed and backfat measurements were obtained by ultrasonic determination[6]. The total number of fully developed pigs born and the number born alive were counted. Pigs were weighed at birth and again at weaning at 28 d of age. To minimize variation in litter size, pigs were transferred among sows irrespective of treatment until d 3 following parturition. Creep feed was not provided and the pigs' access to sow feed was minimal. After weaning, sows were moved to gestation crates and fed 1.8 kg/d of the Gest diet. Sows were checked for estrus once daily in pens using boars. A sow was considered to be in estrus when she stood to be mounted by the boar on 2 consecutive d. On d 15 postweaning, sows were bled if they had not been previously detected in estrus. Weekly blood samples were obtained thereafter until estrus was detected or until termination of the experiment 70 d postweaning. Serum was analyzed for progesterone as described by Anthony et al. (1981) to identify sows that had luteal tissue activity (indicative that ovulation had occurred) in the absence of a detected behavioral estrus. A serum progesterone concentration of >5 ng/ml was considered to indicate the presence of luteal tissue activity.

The effect of the Lo and Hi diets fed during Lac 1 on sow performance from rebreeding to subsequent farrowing was tested using least-squares analysis of covariance (Steel and Torrie, 1980; Helwig and Council, 1979) with the number of fully developed pigs born as the covariate to adjust for litter size differences before diet effects were tested. Analysis of diet effects on sow and pig performance during Lac 2 was performed using a 2 × 2 factorial arrangement of the Lo and Hi diets fed during each lactation. Litter size at 3 d postparturition was used as a covariate. Diet effects on the cumula-

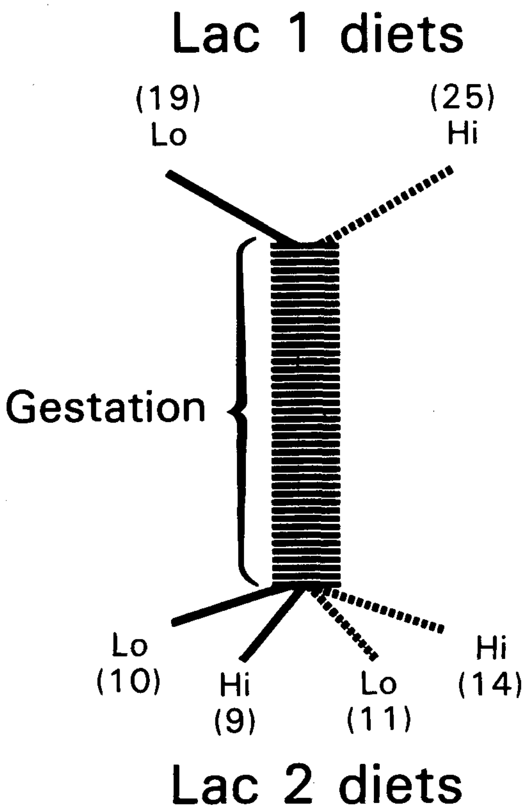

Figure 1. Experimental design. Sows were fed either 8 (Lo) or 16 (Hi) Mcal of ME/d during their first lactation (Lac 1). Sows were remated and fed 5.4 Mcal of ME/d during gestation. Sows fed Lo during Lac 1 were fed Lo or Hi during their second lactation (Lac 2) and similarly for sows fed Hi during Lac 1. Numbers in ( ) represent the number of sows.

[5] 1.8 kg provided 5.4 Mcal of ME/d.

[6] IthaCo Ultrasonic Scanoprobe, Ithaca, NY.

tive percentage of sows in estrus by 7, 14, 21 and 70 d postweaning were tested using a linear model approach appropriate for categorical data (Grizzle et al., 1969). This is distinct from the standard linear model approach for continuous variables because the estrus/no estrus condition is a categorical rather than a continuous response variable. Day of weaning was designated as d 0 in calculating the number of days to first estrus.

Results and Discussion

The effects of energy intake during Lac 1 on the performance of sows from rebreeding to subsequent farrowing are shown in table 1. Sows fed Lo gained more (P = .10) net weight (i.e., Lac 2 postparturition weight minus Lac 1 weaning weight) during gestation than sows fed Hi. Apparently sows fed Lo compensated for their greater weight loss during Lac 1 [indicated by the differences (P<.01) in Lac 1 sow weaning weight]. Previous reports indicate that energy intake (Elsley et al., 1968; Adam and Shearer, 1975; O'Grady et al., 1975) and feed intake (Lodge et al., 1961; Elsley et al., 1969; Hitchcock et al., 1971) during lactation had no effect on net sow weight change during gestation. However, MacPherson et al. (1969) and O'Grady (1971) reported that sows fed low protein diets during lactation tended to compensate by gaining more weight during the following gestation than those fed higher protein diets. Thus, the effect of nutrition during lactation on sow weight gain during the following gestation may depend on the degree of dietary restriction imposed during lactation.

A portion of the difference in weight gain might be attributed to the difference in backfat deposition that occurred. Sows fed Lo during Lac 1 deposited more (P<.01) backfat during gestation than sows fed Hi. Application of the equation of Whittemore et al. (1980) that predicts the total dissectable fat (TDF) as a percentage of live weight, indicates that the percentage of TDF increased by 1.7 during gestation in sows fed Lo compared with no increase in sows fed Hi. Compensation for backfat lost during Lac 1 probably occurred. Backfat loss during Lac 1 was greater for sows fed Lo than Hi as indicated by the difference

TABLE 1. EFFECT OF ENERGY INTAKE DURING LACTATION 1 ON PERFORMANCE OF SOWS FROM REBREEDING TO SUBSEQUENT FARROWING[a]

Item	Diets: Lo	Diets: Hi
Sows		
No.[b]	19	25
Weaning wt (Lac 1), kg[cd]	121.8 ± 2.7	140.4 ± 2.5
Net wt change (gestation), kg[e]	18.6 ± 2.3	13.4 ± 2.2
Postparturition wt (Lac 2), kg[d]	140.4 ± 2.7	153.8 ± 2.5
Weaning backfat (Lac 1), mm[cd]	16.7 ± .7	23.7 ± .7
Backfat change (gestation), mm[d]	2.9 ± .5	.7 ± .5
Postparturition backfat (Lac 2), mm[d]	19.6 ± .7	23.0 ± .7
Farrowing rate, %[f]	76.0	73.0
Pigs		
Total born, no.	9.9 ± .6	9.4 ± .5
Total born alive, no.	9.8 ± .6	9.0 ± .6
Avg birth wt, kg[e]	1.5 ± .05	1.6 ± .05

[a]Least-squares means ± SE. Corresponding F-value for total pigs born as a covariate was 1.72, sow net weight change gestation; 2.46, postparturition weight; .3, sow backfat change gestation; .08, postparturition backfat; .02, average pig birth weight.

[b]Sows detected in estrus ≤35 d postweaning in Exp. 1 (Reese et al., 1982) that subsequently farrowed.

[c]Obtained at weaning in Exp. 1 (Reese et al., 1982).

[d]P<.01.

[e]P = .10.

[f]Calculated by $\frac{\text{Number of sows farrowed}}{\text{Number of sows mated}} \times 100$.

TABLE 2. EFFECT OF ENERGY INTAKE DURING TWO SUCCESSIVE LACTATIONS ON SOW BACKFAT CHANGE DURING LACTATION 2[a,b]

	Lac 1 diets	
Lac 2 diets	Lo	Hi
	mm	
Lo	−5.2 ± .7	−6.3 ± .7
Hi	−1.9 ± .7	.2 ± .6

[a]Least-squares means ± SE.

[b]Interaction (P<.05).

(P<.01) in backfat at weaning (i.e., following Lac 1). Although weight gain and backfat deposition during gestation were greater for sows fed Lo than Hi during Lac 1, sows fed Lo weighed less (P<.01) and had less backfat following parturition (i.e., Lac 2) than those fed Hi.

Farrowing rate (i.e., number of sows farrowed/number mated) was not significantly affected by energy intake during Lac 1. Although farrowing rate was not reported, Lidvall and Griffin (1962), Elsley et al. (1969), Hitchcock et al. (1971) and Varley and Cole (1976) reported that lactation feeding level had no influence on conception rate of sows.

Similarly, energy intake during Lac 1 had no significant influence on the total number of fully developed pigs born or born alive; however, sows fed Lo farrowed lighter weight (P<.10) pigs than those fed Hi. Elsley et al. (1968) and Adam and Shearer (1975) reported that energy intake during the previous lactation had no influence on the number of pigs born and average pig birth weight. Feed intake during lactation also had no influence on litter size at birth (Elsley et al., 1969; Hitchcock et al., 1971; Varley and Cole, 1976) and birth weight (Elsley et al., 1969; O'Grady et al., 1973; Varley and Cole, 1976). O'Grady et al. (1973) reported that the number of pigs born alive decreased as energy intake increased during the previous lactation.

Reasons for the differences in the amount of weight gained, backfat deposited and average pig birth weight are uncertain. Because sows fed Lo during Lac 1 weighed less at weaning than sows fed Hi, their energy requirements for maintenance would probably be less and consequently, more energy would be available for productive purposes. Seemingly, nutrient metabolism during gestation was directed toward preparing sows for the subsequent lactation and postweaning periods possibly at the expense of fetal development because the sows fed Lo during the previous lactation gained more weight, deposited more backfat during gestation and farrowed lighter weight pigs than sows fed Hi.

The effects of energy intake during Lac 1 on sow and pig performance during Lac 2 are presented in tables 2 and 3. Sow backfat loss

TABLE 3. MAIN EFFECT OF ENERGY INTAKE DURING LACTATION 1 ON SOW AND PIG PERFORMANCE DURING AND FOLLOWING LACTATION 2[a,b]

	Diets	
Item	Lo	Hi
Sows		
No.	19	25
Lactation wt change, kg	−6.6 ± 1.9	−8.8 ± 1.8
Percentage in estrus		
≤7 d	68.4	84.0
≤14 d	79.0	92.0
≤21 d	79.0	92.0
≤70 d	79.0	96.0
Pigs		
Avg litter size (weaning), no.	9.0 ± .2	8.7 ± .2
Avg pig weaning wt, kg	5.7 ± .3	6.3 ± .3

[a]Values pooled across Lac 2 diets.

[b]Least-squares means ± SE.

during Lac 2 differed depending on the energy intake during Lac 1 and 2, resulting in an interaction (P<.05). That is, the backfat loss (−1.9 mm) of sows fed Lo during Lac 1, then Hi during Lac 2, was greater than that of sows fed Hi during both lactations (.2 mm). The biological significance for this interaction is uncertain. No other significant interactions occurred, thus only the main effects will be considered (table 3).

Sow weight change during Lac 2, average pig weight and litter size at weaning were not significantly affected by energy intake during Lac 1. The percentage of sows in estrus by 7, 14, 21 and 70 d postweaning appeared lower for those fed Lo than for those fed Hi during Lac 1. Reese et al. (1982) determined that severe energy restriction during lactation (67% of NRC requirements) resulted in a delayed return to estrus following weaning. Sows with reduced weight and backfat at weaning experienced a higher incidence of delayed estrus than those that were heavier and had more backfat. No significant carry-over effect of energy restriction from Lac 1 was observed on estrus in the present study, possibly because of the repletion of body tissues that occurred during gestation.

The main effect of energy intake during Lac 2 on sow and pig performance is presented in table 4. As expected, sows fed Lo lost more (P<.01) weight during lactation than those fed Hi. These results agree with those of Elsley et al. (1968), O'Grady et al. (1975) and Reese et al. (1982). Average litter size at weaning was not affected by energy intake which also agrees with previous reports (Elsley et al., 1968; O'Grady et al., 1973; Reese et al., 1982).

Sows fed Lo weaned ligher weight (P<.05) pigs than those fed Hi. Studies by Elsley et al. (1968), O'Grady et al. (1973), Adam and Shearer (1975) disagree; however, the pigs in the previous studies received creep feed that may have masked differences in pig weaning weights. Reese et al. (1982) reported that the effect of energy intake during lactation on pig weaning weight was variable. Sows fed Lo probably weaned lighter weight pigs than those fed Hi because of a reduction in milk yield.

TABLE 4. MAIN EFFECT OF ENERGY INTAKE DURING LACTATION 2 ON SOW AND PIG PERFORMANCE DURING AND FOLLOWING LACTATION 2[a,b]

	Diets	
Item	Lo	Hi
Sows		
No.	21	23
Lactation wt change, kg[c]	−17.7 ± 1.9	2.3 ± 1.7
Percentage in estrus		
<7 d[c]	52.4	100.0
<14 d[d]	71.4	100.0
<21 d[d]	71.4	100.0
<70 d	76.2	100.0
No. bled[e]	6	0
No. with luteal activity before a detected estrus	0	0
Pigs		
Avg litter size (weaning), no.	8.6 ± .2	9.0 ± .2
Avg pig weaning wt, kg[d]	5.7 ± .3	6.3 ± .3

[a]Values pooled across Lac 1 diets.

[b]Least-squares means ± SE.

[c]P<.01.

[d]P<.05.

[e]Sows bled for progesterone analysis if estrus had not been detected by 15 d postweaning.

O'Grady et al. (1973) reported that milk yield was reduced when second and third parity sows were fed low and medium vs high energy diets during lactation.

Fewer sows fed Lo during Lac 2 expressed estrus ($P<.05$) by 7, 14 and 21 d postweaning than those fed Hi. These results indicate that severe energy restriction during lactation results in a delayed return to estrus, and agree with results reported by Reese et al. (1982). Other investigators (Elsley et al., 1968; O'Grady et al., 1973; Adam and Shearer, 1975) reported that energy intake during lactation had no effect on the number of days from weaning to first estrus when sows were fed energy levels that met or exceeded the requirements of lactating sows according to the NRC (1979). MacLean (1968, 1969) observed that sows that experienced delayed estrus following weaning generally experienced severe weight loss during lactation. Sows fed Lo lost more weight during lactation than those fed Hi; however, the exact relationship between weight loss and estrous activity following weaning is uncertain. Progesterone concentrations support the observations that reproductive dysfunction occurred in sows fed Lo. Six sows fed Lo during Lac 2 were bled for progesterone analysis. None of these had luteal tissue activity in the absence of a detected behavioral estrus.

The data reported herein indicate that energy restriction during lactation is deterimental only to immediate lactation and postweaning performance provided sows are given the opportunity to make adequate gains during the subsequent gestation period.

Literature Cited

Adam, J. L. and I. J. Shearer. 1975. Effects on sow and litter performance of energy intake in lactation and feeding patterns following weaning. New Zealand J. Exp. Agr. 3:55.

Anthony, R. V., R. J. Kittok, E. F. Ellington and M. K. Nielsen. 1981. Effect of zeranol on growth and ease of calf delivery in beef heifers. J. Anim. Sci. 53:1325.

Elsley, F.W.H., M. Bannerman, E.V.J. Bathurst, A. G. Bracewell, J.M.M. Cunningham, T. L. Dodsworth, P. A. Dodds, T. J. Forbes and R. Lavid. 1969. The effect of level of feed intake in pregnancy and lactation upon the productivity of sows. Anim. Prod. 11:225.

Elsley, F.W.H., R. M. MacPherson and I. McDonald. 1968. The influence of intake of dietary energy in pregnancy and lactation upon sow productivity. J. Agr. Sci. (Camb.) 71:215.

Grizzle, J. E., C. F. Starmer and G. G. Koch. 1969. Analysis of categorical data by linear models. Biometrics 25:489.

Helwig, J. T. and K. A. Council. 1979. SAS User's Guide. SAS Institute Inc., Raleigh, NC.

Hitchcock, J. P., G. W. Sherritt, J. L. Gobble and V. E. Hazlett. 1971. Effect of lactation feeding level of the sow on performance and subsequent reproduction. J. Anim. Sci. 33:31.

Lidvall, E. R. and S. A. Griffin. 1962. Effects of limited and full-feeding of sows during lactation on sow and pig performance. J. Anim. Sci. 21:1004 (Abstr.).

Lodge, G. A., I. McDonald R. M. McPherson. 1961. Weight changes in sows during pregnancy and lactation. Anim. Prod. 3:269.

MacLean, C. W. 1968. The thin sow problem. Vet. Rec. 83:308.

MacLean, C. W. 1969. Observations on non-infectious infertility in sows. Vet. Rec. 85:675.

MacPherson, R. M., F.W.H. Elsley and R. I. Smart. 1969. The influence of dietary protein intake during lactation on the reproductive performance of sows. Anim. Prod. 11:443.

NRC. 1979. Nutrient Requirements of Domestic Animals, No. 2. Nutrient Requirements of Swine. Eighth Revised Ed. National Academy of Sciences--National Research Council, Washington, DC.

O'Grady, J. F. 1971. Level and source of protein in the diets of lactating sows. Irish J. Agr. Res. 10:17.

O'Grady, J. F., F.W.H. Elsley, R. M. MacPherson and I. McDonald. 1973. The response of lactating sows and their litters to different dietary energy allowances. 1. Milk yield and composition, reproductive performance of sows and growth rate of litters. Anim. Prod. 17:65.

O'Grady, J. F., F.W.H. Elsley, R. M. MacPherson and I. McDonald. 1975. The response of lactating sows and their litters to different dietary energy allowances. 2. Weight changes and carcass composition of sows. Anim. Prod. 20:257.

Reese, D. E., B. D. Moser, E. R. Peo, Jr., A. J. Lewis, D. R. Zimmerman, J. E. Kinder and W. W. Stroup. 1982. Influence of energy intake during lactation on the interval from weaning to first estrus in sows. J. Anim. Sci. 55:590.

Steel, R.G.D. and J. H. Torrie. 1980. Principles and Procedures of Statistics. (2nd Ed.) McGraw-Hill Book Co., New York.

Varley, M. A. and D.J.A. Cole. 1976. Studies in sow reproduction, 1. The effect of level of feeding in lactation and during the interval from weaning to remating on the subsequent reproductive performance of the early weaned sow. Anim. Prod. 22:71.

Whittemore, C. T., M. F. Franklin and B. S. Pearce. 1980. Fat changes in sows. Anim. Prod. 31:183.